Blast Wave Energy Fluence (Energy/Area), $E_s \approx P \cdot I \cdot C$ for Blast Attenuation Calculations

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Abstract

This paper evaluates the approximation $E_s \approx P \cdot I \cdot C$ for the blast energy per unit area in a blast wave, where P is pressure, I is the blast impulse (i.e., time integrated overpressure or dynamic pressure), and for strong shocks $C \approx 2/[(\rho U)(\gamma + 1)]$ The approximation is dimensionally consistent with $\mathrm{J/m^2}$ and physically interpretable as the work done by a blast wave when interacting with an object. We will use the approximate symbol below, to denote uncertainty in effective duration of the interaction of the blast wave form with the object with which it interacts (e.g., the free field blast waveform with the free field blast duration is not always valid, since a rigid wall may reflect a blast wave back, without being knocked down by it, affecting the duration of the application of force; while a stronger blast wave may quickly demolish the wall).

1 Derivation

Blast energy delivered per unit area,

$$E_s = \int pu \cdot \, dt$$

$$\approx u \cdot I$$

where for strong shocks

$$u \approx 2P/[(\rho U)(\gamma + 1)]$$

$$E_s \approx 2PI/[(\rho U)(\gamma + 1)]$$

2 Dimensional Analysis

$$E_s \approx 2PI/[(\rho U)(\gamma + 1)]$$

$$(\mathrm{m/s}) \cdot (\mathrm{Pa} \cdot \mathrm{s}) = \mathrm{Pa} \cdot \mathrm{m} = \mathrm{J/m^2}$$

The units are consistent.